The use of

GPS In Gaelic

Games

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1) Introduction

GPS is a term that has become more common over the course of the 2013 GAA season, largely due to the obvious use of the technology by several elite teams over the course of the year. As with many training and performance developments, GAA teams are taking their lead from comparable professional sports, in particular the other football codes. The recent rugby union series between the British & Irish Lions and Australia was one of most high profile sporting events during which GPS analysis was evident. The technology is also widespread practice in the Australian Football League (AFL), with most players in the majority of clubs wearing units during every training session and match.

While this gives the impression that we, in the GAA, are doing something modern and progressive to improve training and performance, do we really understand the benefits GPS analysis can provide? The purpose of this paper is to explore some of the current applications of GPS in professional codes, outline some of the potential uses within the GAA, and, identify some of the issues that may need to be overcome to ensure GPS technology can provide long term benefits within Gaelic games.

2) What is GPS?

It is crucial that we are aware of what exactly GPS is, and more importantly what volume of information it can provide to coaches, managers, physios, strength and conditioning personnel and players. GPS is an abbreviation of the term Global Positioning Satellite, and in simple terms what it offers is player movement tracking. In its simplest form GPS uses communication with several orbital satellites to calculate its exact position on the earth's surface. The accuracy of this information is dependent upon several factors. One such factor is the number of satellites onto which the unit is 'locked on'; the more, the better. Another key factor is the signal frequency of the unit, which basically refers to the number of communications between a unit and the satellites each second; once again, the more the better. As noted by Coutts & Duffield (2010), the sampling rate may impact on the quality of the data collected, with a higher sampling rate potentially allowing for the collection of more accurate movement data. At present, a typical GPS unit will operate at 5 hertz (emitting 5 signals per second) and will lock onto approximately 10-13 satellites when offered a clear line of sight. This process allows a unit to be pinpointed to a precise position on the

planet. And through the constant emission of signals this position can be tracked on an ongoing basis to measure the distance the unit has covered, the path it has followed and the speed at which it has covered this distance.

Apart from the GPS tracking, many units also include a number of other instruments all of which combine and integrate to provide tangible outputs for coaches and sport science professionals. One such instrument is an accelerometer. An accelerometer will provide a arbitrary output figure, commonly referred to as player load. Player load is a movement variable that uses the accelerometer in the GPS unit to measure forward, sideways and upwards accelerations to determine a player's external load, although it is impacted by a player's individual movement characteristics (Johnston et al., 2012).

Other instruments include a compass; to record the direction of movement and in particular which direction the player is facing; and, a gyroscope; to measure displacement in angle. The units are also compatible with some heart rate monitors. This enables the integration of heart rate data with the other data attained from the aforementioned instruments, in order to provide a complete description of physical effort.

The use of GPS analysis is a broadening field, but it also subject to much scrutiny in terms of validity and reliability of outputs generated. A significant item of research carried out by Johnston et al. in 2012 to test both these issues with 5 Hertz units concluded that GPS appears capable of measuring fundamental movement demands, which means that feedback can be provided to coaches and conditioning staff regarding the intensity and load of training sessions and matches. However, the same report also advised caution and suggested a need for improvement in the accuracy of GPS technology is necessary before conditioning staff can confidently rely on the data collected at speeds in excess of 25km/h (6.9 m/s or 15.5 mph). Ultimately this paper concluded that 5Hz GPS units be used to measure distance covered, time spent, and number of efforts performed at different speeds zones at low speeds. However, while GPS is also capable of measuring fundamental demands of total distance and peak speed, this paper had highlighted reliability issues.

3) How can GPS be applied in Gaelic Games?

While having this technology available provides an excellent opportunity, the key going forward may be in identifying its potential application in Gaelic games and subsequent research to establish whether certain applications provide more benefits than others. The initial step to identify potential applications has already commenced on a widespread basis. Any user of GPS technology in Gaelic games will have played a role in this step, with most probably having applied the technology in a slightly different way to the next user. However, there will be key similarities that will run through the use of the data collected. The purpose of this paper is to list and explore the various uses of GPS in Gaelic games, through documenting use within Gaelic games to date, but also through reference to other sports and how GPS analysis has been applied across the sporting sphere.

A) Comparison of elite performers to sub elite performers.

In Gaelic games we routinely attribute elite status to inter-county players. We often hear about the increase in fitness levels, among other things, at inter-county level when compared to club level. We also commonly take for granted the fact that there is an additional 10 minutes of game time at county level. To date we have little factual evidence that confirms increased physical demands at county level when compared to club football, although there is a widespread belief that it is required of the players. There is a role for GPS to quantify just what extra demands, if any, are placed upon players when stepping up to county level. There are many practical implications of having access to this data.

Firstly, to inform inter-county coaches and players of just what demands will be placed on them during a 70 minute match. Assessing these figures may be alien, and indeed inconvenient, for many players, but some will no doubt take note of the findings and delve deeper into their meanings and how to effect improvements going forward. Likewise some managers will not be interested in GPS findings, but conditioning coaches and football coaches should be paying attention to the findings. GPS outputs could provide conditioning coaches with the information required to accurately address the correct aspects of fitness in order to prepare players to compete for the full match duration. At the same time, awareness of physical demands of the game could provide coaches with important information regarding how to train a team tactically, or even how to maintain skill levels following maximal exertions over the course of a match.

Secondly, measurement of current inter-county players could provide vital information for players that aspire to such heights. There are many excellent club players who struggle to make the grade at county level, but with some basic GPS information coaches may be able to direct them more precisely to where physical improvement is needed. Even more importantly, for the aspiring county underage player attempting to take the step to senior grade, this information could be very valuable as part of the process of development.

Finally, within inter-county Gaelic teams there are a range of levels; an elite within the elite. It is possible that GPS analysis across the country could reveal significant differences in physical outputs depending upon the level that a team is competing at. However, even if there is no differentiation then coaches can at least rule this out as a cause of inferior performance, and may choose to spend greater time on skill and tactical development, as opposed to closing a physical gap that does not actually exist.

A study by Brewer et al. (2010) in Australian football compared movement patterns in the elite AFL to that of players in the sub elite WAFL using GPS analysis. The study concluded that movement demands were significantly greater in AFL than WAFL matches. An interesting aside to the conclusions of this study lies in the fact that comparison was made between 2 varying groups with differing playing times. Despite the AFL and WAFL registering similar values the AFL players were generating figures based on less playing time, which signifies a higher intensity. The reason this is of interest is that in Gaelic games we are likely to encounter varying playing times between our elite and sub-elite squads also.

A similar study in field hockey (Jennings et. Al. 2012) found that international (elite) players completed more high speed running than players at an elite national level (sub elite). They were also able to conclude that attackers and midfielders performed more high speed running than defenders, and, that activity demands decreased in the second half.

B) Real time match performance analysis: physical outputs and how they compare with targets;

Current GPS technology has the capacity to communicate, via an antenna, in real time, with a laptop positioned pitch side. The outputs available in real time are confined to the values produced by the GPS data, and are fewer than those available in the retrospective analysis platform, but nonetheless provide a substantial volume of data to interpret. The parameters available include distances covered in the various speed zones, number of efforts in each zone, current speed and heart rates zone data, among others. Despite this available technology caution is required when using real time data to monitor performance, and coaches should be aware of the magnitude and likely range of error which was evidenced through a study by Aughey & Falloon (2009). This study observed surprisingly low concurrent validity between real time data collected and post game data. However, it is important to note that this study was carried out in 2008, and published in 2009. There has been significant development of the technology over the past 5 years, with several updated models becoming commercially available. Unfortunately there appears

to be little in the way of up to date published material that has assessed the correlation between real time and post game values for these upgraded models.

Aughey & Falloon (2009) noted that despite supporting literature, many Australian Rules football teams had commenced using real time GPS data to make decisions on player performance, and inter change strategies during matches, with targets set based on historical data, usually obtained through post game analysis. A subsequent review of GPS technologies by Aughey (2011) explained how GPS had been applied to detect fatigue in matches, identify periods of most intense play and identify different activity profiles by position, competition level and sport, with more recent research focusing on game specific tasks or tactical and strategic information. It is clear that there is an almost endless evolution of applications of GPS technology, and more specifically the use and application of real time data.

Some field sports codes, in particular AFL and the rugby codes, have progressed to the point where real time GPS outputs are used to guide decision making in terms of substitutions. It is certainly conceivable that this could be useful within Gaelic games, with many managers using certain players, in certain positions, almost to the point of exhaustion before making a personnel switch. Many managers that employ this strategy generally make the call at a set time in the match, or when the player indicates they have hit their limit. There are dangers in both aforementioned strategies in that a call may be made a few minutes before or after exhaustion, and this could have repercussions in terms of the match result. However, with a robust system, predominantly using historical post game analysis data, it could be possible to identify the exact moment when a player has hit their limit through real time GPS data. This could potentially be when a player has accrued a certain distance, or perhaps when a measure of intensity has markedly fallen (e.g. distance per minute or work: rest ratio). Similarly, it may also be possible to use real time data to identify unexpectedly low work rates among players and address any issues before they have a significant impact upon the outcome. For example, a player may have recently returned from injury and been declared fit, but it may become evident early during a match using GPS data that a player is not fully fit, and cannot deliver the required work rate, thus allowing a switch to be made.

Another potential use of real time data may be in positional or tactical approach. At certain stages during a game it may be feasible to identify if certain players have been subject to a short term heavy workload and may need momentary respite. This can be addressed with a simple positional switch to allow for this respite. On a more general basis, it should be possible to identify if the team in general have been subjected to a short term intense phase of work, and it may then be possible to communicate a message to tactically slow or delay the game to allow for slightly longer recovery. Alternatively, the GPS data might provide evidence that the team is comfortable, and it may be obvious to the eye that the opposition have been worked hard, so a message may be communicated to increase the tempo and exploit opposition weakness.

There is a surprising lack of documented study to observe the relationship between real time GPS outputs and successful performance. It is obviously a difficult area to analyse, and problematic in terms of the range of parameters that can have an impact upon performance, and thus is almost impossible to assess which parameters correlate to successful performance. However, over a prolonged period of time it may be possible to identify correlation between at least one parameter and successful performance. Trial analysis carried out by Ulster GAA during the early stages of the 2013 season identified a method by which ongoing analysis could be structured and quickly and easily analysed for patterns. The method focused upon observing the game in 5 minute intervals, measuring the scoring patterns and subsequent correlation with a selection of real time parameters. While no

results were published, there were some encouraging signs that a wider scale study may be able to uncover a direct link between at least one parameter and successful outcome.

C) Managerial Decision Making Process

Not surprisingly, published material assessing the impact of GPS on management decision making is nonexistent. It is highly unlikely that many managers will openly admit to, nor disclose to what extent, they pay attention to GPS outputs when making decisions regarding team selection, player substitution and tactical approaches. It is fair to speculate that many managers base decisions on instinct and their trained 'eye for the game', and rarely if ever refer to GPS outputs. However, a higher percentage of coaches and fitness trainers will refer more regularly to GPS outputs in conjunction with their instinct and knowledge.

Going forward it is important to establish if and how GPS outputs can be integrated with the trained eye of the coach to improve the decision making process. It is undoubtedly a complicated area with significant pitfalls should there be incorrect decisions made which impact upon results. The suggestion at present would, not surprisingly, be that a coach and / or manager continue to make all decisions and observations based on their own knowledge base. However, the ongoing education of the capabilities of GPS analysis should be practiced and where possible used to cross reference any observations a coach may make. As a typical example, if a coach feels a player is not performing to an acceptable standard they could refer to the GPS outputs to confirm their feeling and then act accordingly, perhaps through a substitution to get a fresher player on. However, the GPS outputs may prove that the initial feeling the coach had was not totally accurate and this may lead to an alternative course of action, possibly in the form of a positional switch for the player in order to change the challenge they are faced with.

D) Ongoing Player Loading Management

This general concept is highly intricate and has several potential sub sections into which certain aspects of this system could be allocated. In the simplest terms, GPS player tracking could provide a tool whereby individual physical outputs for every player could be measured and recorded for every session over the course of a season. This sort of system could provide untold benefits within the GAA, in particular to team management and coaching personnel, strength and conditioning personnel, medical support staff and other affected coaches. It could also provide information that could be of benefit both in the short / medium term period and on a more long term basis.

Firstly, team management and coaching personnel could benefit from information which could potentially inform them of variance in fitness levels between players, patterns in fitness of a single player over time, effort and work rate in certain circumstances, monitoring of activity levels when outside of the squad environment, and no doubt a range of other benefits. The ability to add factual data to their observations and thoughts could provide a useful supplement to either firm up their instinct, or provide an alternative interpretation of player performance. Overall the information could provide an additional aid to the decision making process, in terms of team selection, positional deployment, team tactics and substitution strategies. As an example, a coach might be able to assess a player on the short term through measurement of match outputs against a team mate in a similar position. On the medium term, a coach could use an early season game as a reference point when measuring mid or late season match performance. And in the long term, a coach could assess like for like match outputs for the same player using data from previous seasons. Obviously there are numerous variables that can affect outputs, but with an ongoing collection process it should be possible to accrue data for almost any situation that a team is likely to encounter over the course of a season.

Secondly, strength and conditioning personnel can use an ongoing system to measure player progression across a range of parameters. Short term application may enable for a programme to be tailored or amended in order to ensure players are achieving previously agreed physical performance goals. On a long term basis strength and conditioning personnel may be able to assess any perceived weaknesses over the previous time period and plan and implement strategies to avoid a repeat of the same weaknesses. A topical example within GAA may be that a team looked tired towards the end of season, and perhaps were not looking as physically capable as their opponents. Therefore, for the next season the strength and conditioning personnel can adjust the periodisation of the programme with the aim of maintaining freshness to the later stage of the season, with the GPS data allowing for monitoring of workloads.

Perhaps the most notable possible benefit is how GPS data could aid medical personnel in the battle to prevent injuries and effectively manage the rehabilitation process where necessary. Short term data could play a major role in the process of rehabilitation, with GPS data allowing physiotherapists to manage training loads placed upon the body, but also to measure how close a player is to replicating physical outputs demonstrated pre-injury. There is also the ability of GPS to allow the rehabilitation routine to expose the player to match specific physical demands without the need to expose the player to match conditions and run the risk of injury setbacks. The long term application from a medical standpoint is potentially one of the most important uses of GPS data in terms of player management. Through development of an injury analysis database, in particular overuse injuries it should be possible to assess a range of GPS outputs in the lead up to an injury occurring. There is likely to be at least one, if not more 'warning' signs evident within the GPS data that may have pre warned of the potential for injury. If these key figures can be identified then it should be feasible going forward to monitor certain parameters on an ongoing basis and have established 'trigger' points, at which stage individual training load should be evaluated and amended in order to avoid injury occurring and an extended period of time on the treatment table. While this is feasible on an individual basis, it may also be possible to identify certain training periods or activities that appear to trigger common issues within the wider squad setting. As an example, after a certain training block during pre-season a number of players are seeking treatment for 'tight' hamstrings. Analysis of the GPS data might show a heavy, concentrated volume of accelerations and decelerations which are likely to have caused the issues. Liaison with the strength and conditioning personnel may allow for an amendment of this activity in order to limit the potential for future issues.

Finally, within the GAA we are presented with a somewhat unique structure that can see some players training and performing for numerous teams concurrently, often with incompatible calendars in terms of periodisation and training focus. These teams can include schools teams, university teams, club teams, club underage teams, county teams and county underage teams, and in some cases we even see an individual performing across both codes. Many attempts have been made in an attempt to protect these players from the rigours of multiple training regimen but many have demonstrated limited success. The use of GPS tracking data could provide an innovative solution to the ongoing problem of overtraining. Through monitoring every session, with each team an individual can gather a profile of training load over an extended period of time. Essentially, this training profile could provide factual evidence of fitness levels and training focus for the individual, which can be available to all coaches seeking their 'pound of flesh'. Despite the availability of this data, the application to training is still dependent upon understanding and acknowledgement by all affected coaches, and possibly through the appointment of one coach to oversee the overall training regime. GPS data by no means offers a perfect solution, but it can act as an effective tool to quantify the exact level of physical demands being placed upon one single player.

In summary, ongoing analysis through GPS data can provide an excellent reference tool for a range of support personnel in order to ensure each individual is provided with the most efficient physical preparation possible.

However, it also offers the opportunity for support personnel to critique their own approach in the hope of making improvements, however small, moving forward.

E) Injury Prevention and Rehabilitation Management

An ambitious application of GPS tracking is to strive towards a scenario whereby the data can be used initially to monitor loads and perhaps prevent the occurrence of overuse injuries, but also to carefully manage the re-introduction of injured individuals to the demands of full training and ultimately match situations.

In order to use GPS data to prevent injury there is a need for prolonged collection of training and match data for each player. There is also a requirement to maintain an accurate and detailed diary for each player focusing specifically on injury occurrence and condition, muscle and joint soreness and general well being. While it is not possible to link GPS outputs to traumatic injuries that typically occur in GAA (e.g. dead legs, shoulder dislocations, bone breaks and fractures) it is possible to attempt to link the outputs to chronic / overuse injuries, muscle strains, pulls and tears and potentially even to ligament tears and strains. Unfortunately for the system to be effective in future it is dependent upon the occurrence of injury in each player.

For example, if a player has suffered a mild strain of a hamstring, it should be possible to trawl the immediate history of their training loads and search for any triggers that may have caused the injury. It is unlikely that there will be a single specific causal factor. However, the medical and sport science personnel should be able to record the loads this player was subjected to immediately prior to experiencing this strain. Going forward, this player could be monitored and if a similar loading pattern is developing it may be possible to slightly adjust training in order to maximise training effect without over reaching and effecting a recurrence of the hamstring strain.

This system is not likely to be successful based upon short or even medium term data collection, but over the course of several years it has the potential to significantly impact upon the occurrence of overuse injuries.

Regardless of any injury prevention system, it is safe to say we will continue to have a significant volume of injuries that require treatment, management and rehabilitation. GPS tracking offers another tool which the personnel involved in the rehab process should be able to make extensive use of. The typical rehab process often includes a period of time being managed by a physiotherapist, before the player is 'handed over' to strength and conditioning personnel and ultimately back to the first team coach for inclusion in full training. Unfortunately this process often includes a regression back to physiotherapist due to a recurrence of injury. This recurrence is rarely due to poor practice by the strength and conditioning coach, but usually a combination of misinterpretation during the hand over and insistence by the player that they are capable of greater volume or intensity, or both. GPS tracking has the potential to make the transition from injury back to full match fitness a better managed process throughout.

Firstly, GPS tracking can offer medical personnel a platform to monitor load even after hand over to the various other coaches. In the real time application this may even include introduction of warning triggers which will alert the player when they have achieved certain goals, or maybe when they are at an upper threshold in terms of intensity. This should eliminate misinterpretation and player misguidance as they progress with their rehab programme, while at the same time allowing the physiotherapist to revert to treatment of other injured cases in the knowledge that they continue to maintain control over training load of their rehab cases.

Secondly, in the later stages of rehab both the medical and strength and conditioning personnel can make use of GPS outputs to monitor how 'match ready' a player is. Through reference to historic match based data for this player it should be clear if the player has replicated outputs from prior to the injury occurring. It can provide useful feedback

for coaches and the player in terms of the final steps required in order to refine their fitness in preparation for reintroduction to match situations.

F) Training Analysis and quantification / classification of training activities;

This is another area which could provide a range of sub sections in terms of the application of GPS tracking. Predominantly coaches will seek to use GPS to monitor volume and intensity of standalone sessions. However, it is conceivable that GPS could be used to maintain an ongoing profile of training, to compile a database of training activities and quantify activities into categories of intensity or volume for future reference and to quantify, compare and contrast differences in effort levels or physical pressure experienced by players.

For a single session GPS tracking can enable a coach to motivate players while at the same time measuring the effectiveness of the session with regard to the goals they had set for the session. However, on an ongoing basis GPS tracking should allow coaches to gain a visual representation of the balance between load and intensity. At certain stages of the season intensity may be relatively low, but volume may be high, while the opposite may be true closer to competition.

Through careful management of the GPS system it is possible to isolate each distinct training activity for analysis. With this information it is then feasible to allocate each activity into a several categories, which may include the focus of the activity and the physical intensity. Over a period of time it should allow coaches to compile a database of training activities which can be referenced according to their training focus and intensity. In theory this could make planning future sessions a simpler process in terms of activity selection, but also from the point of view that there is already knowledge to confirm how hard the players will have to work during the activity. Specifically, if a coach wants to work at a moderate intensity on tackling, they can refer back to the database for tackling activities. They can then select a moderate activity from the list of tackling drills previously completed.

It is fair to suggest that in the majority of sessions coaches will want all players to be working at a similar level. Real time GPS analysis can help coaches to ensure that all players are committing the same effort to the session. It will also allow the coach to identify any issues early and address them before the session is over. If several players are not working at the same intensity and the GPS data confirms this, the coach could identify those players and instruct an extra activity to ensure the training effect is attained. On a broader basis, if the coach is made aware that no player is attaining the levels required it is possible to adjust the training in order to reach the goals, either through a change of activity or addition of conditions and rules to effect increased intensity.

G) Physical Testing / Assessment

The potential of GPS technology to impact on fitness assessment is fairly limited at this stage, and until there is greater clarity of validity and reliability of the technology this is likely to remain the case. Within some AFL test batteries players are instructed to complete a set distance in as quick a time as possible while wearing GPS units. Results are subsequently analysed to assess time and speed zone profiles during the completion of the test. However, use of GPS to complete standard field testing is not likely unless there are significant reductions in cost and improvements in reliability and validity.

Despite this, there is an argument that GPS analysis could, in future, eliminate the need for field based testing. Analysis of players during training / matches as previously outlined could conceivably provide coaches and trainers

with all the data they require to assess player fitness profiles. GPS analysis could provide trainers with an overview of a player's running capability at a range of speeds and intensities, while also assessing their recovery ability between high intensity bouts. Essentially, GPS technology could enable coaches and trainers to devise new tests, and subsequent protocol, which will specifically assess an individual's ability to replicate match demands.

H) Identification of parameters that potentially correlate with success

It is conceivable that within the range of GPS parameters there are a number that may correlate with successful performance and outcome; in Gaelic games this could be outlined as positive scoring balance. At this early stage of GPS analysis within Gaelic games, it is too early to definitively distinguish which parameters correlate with performance. However, this is one area that is ideal for widespread study in order to identify any patterns that may exist. In practical terms, if it is possible to identify certain physical outputs that correlate with successful performance it can provide trainers and coaches with further evidence to guide physical training.

In theory this concept could be construed as being the 'holy grail' of training for performance. That is, identification of key physical outputs and to what extent they are required in order to maximise the chance of success. A similar concept has become prevalent in professional cycling, with Team Sky re-writing the tactical approach of professional cycling teams. Ultimately, through a thorough and exhaustive application of statistical analysis and sport science, Team Sky was able to identify the limits for each of their riders in a range of circumstances during their training schedules. Come race day, all riders were fully aware of their role within the team, and the intensity / duration they could sustain. Followers of professional cycling will be well aware that Team Sky regularly set a high pace during stage racing, safe in the knowledge that any rider who attempted to breakaway would be unlikely to be physically capable of maintaining their intensity for the duration required. Team Sky had already established that they would be capable of sustaining certain intensities for the required duration, and subsequently maintain this pace in order to dilute and hopefully eliminate the threat from their opposition.

If this same concept could be applied to Gaelic games, it would provide trainers and coaches with unprecedented levels of information upon which to base both training and tactical approaches. However, what we must remember is the dynamic nature of Gaelic games, the presence of direct opponents, the dependence of physical outputs upon successful skill execution and the tactical approach of any particular team. When we consider all these factors it becomes almost impossible to directly link physical outputs to successful performance. However, that is not to say that some parameters may correlate with positive scoring patterns and this is an area worthy of investigation over the coming years.

I) Tactical Analysis

The latest technological developments from the manufacturers of player tracking technology have exhibited the potential for ball tracking combined with player tracking. Should this become widespread the implications for tactical analysis cannot be overstated. Current technology can enable a coach to observe the position of all his / her own players on the pitch if they are fitted with appropriate equipment. Coupled with synchronised video footage of the same game this can provide a coach with an excellent analysis and feedback tool. As a specific example within Gaelic games, should a team be struggling to convert possession to scoring chances due to a lack of penetration a coach could use GPS tracking to analyse movement patterns and identify where improvements and / or alterations could be made. It is fair to argue that this could be carried out through effective video analysis, however the GPS outputs can provide a total overhead view which can provide an unobstructed view of the angles and movements exhibited. A combination of both video and GPS tracking could provide a coach with a complete analysis tool, but also an excellent feedback tool when dealing with players.

J) Player Positioning

As a follow on from the tactical analysis potential, player tracking could also provide an excellent tool for one to one positional analysis. As the tactical evolution with Gaelic football continues apace many coaches deploy their players to fulfil certain roles, and take up certain positions, both when in possession and when defending. As with team tactical analysis, a combination of player tracking outputs and video footage can allow a coach to identify how a player was positioned at certain stages of matches. Again, specifically within Gaelic games, if a coach notes that his / her full forward is gaining plenty of possession but not delivering sufficient scores, he / she could check the GPS tracking and might discover that the full forward's starting position is too deep, which in turn results in gaining possession too far out from goal to deliver scores. This could result in useful feedback for the player in terms of their own positioning, but could also translate to general team feedback in term of the need to deliver the ball from more advanced areas of the pitch to ensure the full forward does not need to drift out to gain possession.

It is evident from the above that the potential applications of GPS / player tracking are plentiful. However, it is also clear that there remain plenty of obstacles to the widespread use of this technology within Gaelic games.

4) What are the big obstacles?

The obvious obstacle that we face within the GAA to this level of analysis is cost. With individuals units costing anywhere between £1,000 and £5,000 the cost for 15 players could range from £15,000 up to £75,000. As with anything, the more expensive units are typically the better, more accurate and more reliable units. Regardless, few counties are likely to allocate this level of funding to the purchase of player tracking technology.

Where a county may be willing to invest in this technology, another key obstacle to effective use and application is the availability of suitable expertise. Due to the scarcity of the equipment within Gaelic games, the volume of personnel comfortable with using the technology, interpreting the data and applying the findings are severely limited. However, as with most technologies, many of the system are easy to use, with the software interface being very user friendly and straight forward to use. There are many top quality sport science graduates available within Ireland who could effectively use this technology and provide useful feedback for coaches.

Despite the advancement and refinement in the development of the units they continue to require the athlete to wear a vest into which the unit is secured. It is fair to suggest that the majority of players do not find the vest to cause any discomfort or hindrance to performance. However, there is a small percentage of players who object to wearing the vest, or indicate that they are uncomfortable wearing the vest. This is certainly an area where the GAA could directly influence through discussions with their official kit manufacturers. It may be possible to integrate a pouch into the jersey so as to save the need to wear a vest underneath the jersey.

Finally, one of the key obstacles to widespread use of player tracking is the lack of knowledge and subsequent lack of confidence that many of our coaches will feel when presented with both the technology and / or the reports. The use of technology to guide training and analyse match performance will become increasingly widespread as time progresses. Typically, within the GAA many of our coaches have been slow to embrace new developments and explore their uses. In many cases the resistance could be justified as the technology failed to endure. However, if we observe the alternative global football codes, all of which are professional, the use of player tracking is widespread. The associated technology is likely to not just endure, but continue to evolve. With evolution should come affordability, so within the next 5-10 years it is vital that our coaches within Gaelic games make the attempt to adapt and learn what they can do with player tracking information.

Summary

It is important firstly that we understand that GPS monitoring is no longer solely GPS monitoring, and is more appropriately described as athlete tracking, given that within the unit there are now GPS monitors, accelerometers, gyroscopes and compasses included, as well as potential integration with compatible heart rate monitors.

The list of potential uses of athlete tracking is only limited by the imagination of the user essentially. How best to use the data may depend very much upon an individual's role within the team, but given that one session can provide information suited to all users makes the use of athlete tracking all the more appealing. For example, a strength and conditioning coach may focus specifically on the volume of high intensity running and recovery periods demanded of a player during a game in order to better tailor training sessions to replicate match demands. While the team physio might use GPS data to measure effort during a rehab program in order to avoid overloading the recovering player too quickly, likewise, the physio might also use the data to measure how close the player is to replicating pre-injury figures. The manager might use the athlete tracking to observe player positions and tactical approach if they feel certain patterns of play are not working sufficiently well.

While the potential uses of athlete tracking are widespread, unfortunately the same applies when focussing on obstacles to its use. Within the GAA the biggest obstacle is cost and availability to teams and players. Hopefully through the evolution, development and refinement of technology cost will lower in the coming years which should in turn make athlete tracking technology more accessible to the wider GAA world. However, it also must be acknowledged that, even if the technology becomes available, there are obstacles in the form of experienced personnel to use the units, player willingness to wear the units and coach /manager attitude to the need for technology. Within the coming 2-3 years it is important that the GAA begin to embrace this technology as much as possible.